US LHC Accelerator Project	Baseline Change Request
BCR Number	42
WBS	1.1.2.5, 1.1.1.6.2, 1.1.1.6.3, 1.1.1.7.2.4, 1.1.5
Title	IR Layout and Integration
Change Control Level	2
Originator	J. Kerby / M. Lamm / R. Bossert
Date	1April 2002

Description of change

This BCR provides additional budget for several WBS elements related to the integration of the inner triplet system. The tasks addressed are related principally to the electrical system of the inner triplet: the design of the main, corrector and power busses, the construction of mockups to prove the design, and an adjustment to the cost of the components and their assembly based on the design that has been developed. The specific WBS elements affected are the following:

1.1.1.2.5	Cold Mass Q2a/Q2b Parts
1.1.1.6.2	Q2 Assembly and Test
1.1.1.6.3	Q1/Q3 Assembly and Test
1.1.1.7.2.4	Cold Mass Q2a/Q2b EDIA
1.1.5	IR System Design

Additional cost has also been incurred on the IR System Design WBS element (1.1.5) to cover Fermilab support of the DFBX task at LBL: testing of the prototype HTS leads at CERN, and increased oversight of the design effort. BCRs have been submitted to create new WBS elements to cover future activities at Fermilab in support of the DFBX: BCR 43, "Fermilab work on DFBX," which has been approved, and BCR 44, "HTS Lead Testing at Fermilab," which is in preparation. However, charges related to the DFBX have been made against WBS 1.1.5 prior to the approval of these BCRs.

Across these WBS items, the estimated variance at completion based on the current BAC is 670.9k$, of which as of the 31 March 2002 cut date 279.1k$ is present in the FNAL-LHC Cost Variance and the remaining 352.9k$ is in the Variance to Complete. However, the current cost variance in 1.1.1.6.2, is related to touch labor on the assembly of the first quadrupole magnets, and is unrelated to this BCR. Therefore, the requested change in the budget at completion is the net of these two, or 495.6k$.

Reason for change

Closure on the interfaces of the inner triplet quadrupoles is taking longer than anticipated. Originally the effort was expected to ramp down in early FY2002. Current experience shows this will not happen until late 2002.

In addition, parts and labor for the fabrication of the main and corrector bus work, interconnect wiring connections, expansion loops has been re-estimated based on the current design, and shows a significant increase in expected costs.

The scope of the changes can best be described in parts. First, the integration effort as contained in WBS 1.1.5 has been defined to include the oversight and design activities associated with the inner triplet quadrupole system as a whole. In practice this has meant in particular the electrical and overall cryogenic system layout and design for the Q1-Q3 system. Since the processing of BCR30 with a cut date of June 1, 2001, completing this effort has diverged significantly from the baseline.

There are several root causes: completion of bus work mockups and closure with CERN on design details is taking more time than anticipated, and impacts the continuing design effort such that it has not ramped down as quickly as anticipated. Secondly, the development of a better and more detailed design of the bus layout has led to the development of a detailed cost estimate for these parts and the touch labor required for their production. Finally, this WBS has been used for other effort not originally in the baseline description, including the supervision of HTS lead testing at CERN in November 2001, and the creation and testing of a series of splice tests in February/March 2002 at Fermilab in response to CERN comments.

Table 1 shows the monthly hours in the baseline for the period June 2001 – March 2002, and the actual hours charged to the WBS in the same period.

Table WBS 1.1.5 Baseline / Actual Comparison

WBS 1.1.5 Basline	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02
Physicist	74	74	81	64	40	35	32	37	33	37
Engr (DAT)	37	37	40	32	20	18	16	18	17	18
Designer	147	147	161	128	0	0	0	0	0	0

WBS 1.1.5 Actuals	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02
Physicist	104	69	54	58	72	166	54	100	63	46
Engr (DAT)	32	35	56	35	36	59	54	70	67	64
Designer (DAT)	0	0	0	0	0	0	0	18	59	0
Sr Op Spec (DAT)	0	0	0	0	0	0	0	0	0	24
Tech (DAT)	0	0	0	0	0	0	0	0	0	80
Engr (EFD)	25	23	18	48	90	2	0	10	0	0
Designer (EFD)	36	56	56	242	243	104	101	79	30	71
Drafter (EFD)	24	56	21	10	34	24	120	102	0	116
Tech (EFD)	0	141	152	24	65	36	32	14	0	138

Physicist effort in this WBS is focused mainly on the electrical design of the inner triplet, and completing interfaces with CERN with respect to bus work, splices, connectors, heaters, and general wiring. The ramp down anticipated in the baseline did not occur, but has stayed flat over this timeframe, with two upward spikes. In November-January HTS lead testing support (about 140 hours) was supplied to the program and charged to this code (for lack of a better place), and in January there is more effort in preparation for the cryostat and interconnect design reviews.

Engineering effort from the DAT (development and test) department in this WBS covers the triplet cryogenic system oversight and layout. As opposed to the ramp down in the

baseline, this effort has remained constant, a combination of continued definition with CERN and picking up later in the year oversight associated with the DFBX design (about 200 hours). Compared with the baseline of 253 hours, over the time span included in Table 1 508 hours were spent on the cryogenic system oversight, with the effort actually ramping up in October / November as opposed to the expected ramp down.

Designer and drafting effort comes from two groups, development and test and engineering and fabrication. This engineering and fabrication department effort is focused on completing the electrical layout and detailed design of the main and corrector bus work for the inner triplets, including expansion loops, and the development and test department the connectors and connector hold downs for the quench protection, voltage taps, and cryogenic heater systems. This effort was underestimated in the last baseline, and has proven much more labor intensive than expected.

The engineering effort from the engineering and fabrication department is oversight for the designer and drafters from that department, and the development of bus schematics in consultation with the physicist effort.

The technician effort from July through January has been devoted to building mockups of the main and corrector bus routings in IB3. The Senior Operations Specialist and all technician effort in March was devoted to the assembly and cryogenic splice tests, in response to questions brought up by CERN at the design reviews.

Impact on other sub-systems

None.

Impact on cost

The estimate of the effort to complete from 1 April 2002 was re-done from the bottoms up, and is summarized below in Table 2.

US LHC Accelerator Project	Baseline Change Request
BCR Number	42
WBS	1.1.2.5, 1.1.1.6.2, 1.1.1.6.3, 1.1.1.7.2.4, 1.1.5
Title	IR Layout and Integration
Change Control Level	2
Originator	J. Kerby / M. Lamm / R. Bossert
Date	1April 2002

Table 2. Summary of BCR 42 Changes (ETC from 1 April, FY01$)

	WBS	Date	New		Old		net	notes
			hours	k$	hours	k$	k$	
Bus/Hypertronics Parts	1.1.1.2.5.4.9	2002-2003		87.2		79.1	-8.1	Appendix 1
Touch Labor - Q1	1.1.1.6.3	2002-2004	1,116	35.3				Appendix 2
Touch Labor - Q2	1.1.1.6.2	2002-2004	2,268	71.8				Appendix 2
Touch Labor - Q3	1.1.1.6.3	2002-2004	3,420	108.2				Appendix 2
Touch Labor - Mockup	1.1.5	2002	350	11.1				Appendix 2
Touch Labor - Splices	1.1.5	2002	0	0.0				Appendix 2
Touch Labor - 1st Item	1.1.1.6.2	2002	350	11.1				Appendix 2
Touch Labor - Total			7,504	237.4		0	-237.4	Sum Appendix 2
EDIA - EQB Engr (EFD)	1.1.1.7.2.4	2002	219	13.3	656.5	39.9	26.6	Appendix 3
EDIA - EQB Drafter (EFD)	1.1.1.7.2.4	2002	109	4.5	175	7.2	2.7	Appendix 3
EDIA - LLI Engr (EFD)	1.1.5	2002	219	13.3		0	-13.3	Appendix 3
EDIA - LLI Designer (EFD)	1.1.5	2002	365	15.5		0	-15.5	Appendix 3
EDIA - LLI Drafter (EFD)	1.1.5	2002	401	16.5		0	-16.5	Appendix 3
EDIA - Phys (DAT)	1.1.5	2002	219	14.5	218.8	14.5	0.0	DAT Estimate
EDIA - Engr (DAT)	1.1.5	2002	193	11.2	109	6.4	-4.9	DAT Estimate
EDIA - Des (DAT)	1.1.5	2002	40	1.7		0.0	-1.7	DAT Estimate
Total (k$) in FY01$							-270.9	
cut date is April 2002								

With the electrical design complete, including drawings, a detailed estimate of the parts was completed. This re-estimate is shown Appendix 1, and gives a net increase of 8k$ in parts above that already included in the baseline. This is line item 1.1.1.2.5.4.9 in the current WBS, and will be kept in the same location.

The touch labor necessary to complete the R&D effort (mockup), and do the production assembly of the bus work has been estimated based on our limited direct experience to date and is shown in Appendix 2. The mockup labor we will continue to charge to WBS 1.1.5; production labor shall be charged to the cryostat production labor codes, either Q2 (1.1.1.6.2) or Q1/Q3 (1.1.1.6.3). Note that the production effort was estimated for the whole electrical effort. However, that which is a duplication of effort already done while completing the prototype magnet Q2P1 is then subtracted out, as it was already included in the BCR30 description.

Table 3 shows a summary of the charges expected for the remainder of the year on WBS 1.1.5. In parts it is a duplication of portions of table 2, however put in a manner where a direct comparison to the accumulated actuals shown in Table 1 can be made.

US LHC Accelerator Project	Baseline Change Request
BCR Number	42
WBS	1.1.2.5, 1.1.1.6.2, 1.1.1.6.3, 1.1.1.7.2.4, 1.1.5
Title	IR Layout and Integration
Change Control Level	2
Originator	J. Kerby / M. Lamm / R. Bossert
Date	1April 2002

Table 3 BCR 42 System Design Effort

WBS 1.1.5 Baseline	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02
Physicist	37	37	37	36	36	36
Engr (DAT)	19	18	18	19	18	18
Designer						

WBS 1.1.5 BCR42	Apr-02	May-02	Jun-02	Jul-02	Aug-02	Sep-02
Physicist	37	37	37	36	36	36
Engr (DAT)	36	36	36	33	26	26
Designer (DAT)	20	20				
Sr Op Spec (DAT)						
Tech (DAT)						
Engr (EFD)	37	37	37	36	36	36
Designer (EFD)	219	37	37	36	36	
Drafter (EFD)	109	73	73	73	73	
Tech (EFD)			120	120	110	

The effort is expected to ramp down to the planned FY03 effort at the end of this year. In short this BCR delays the ramp down of effort from that in the previous baseline, because of our difficulties achieving closure with CERN, and acknowledges the effort was more difficult than we expected in the first place.

The total impact on cost to complete can be summarized by WBS code in table 4, which shows a total, fully loaded increment of 391.8k$ to the project's March 2002 budget to complete (Variance to Completion = VTC = BTC-ETC). Combined with the past cost variance of –$279.1k (actual cost larger than budgeted cost), this yields a VAC of $670.9k$, summed over the WBS elements in Table 4. Correcting for the current cost variance in 1.1.1.6.2, the net budget increase is 495.6$. The new budgets for each of the affected WBS elements are shown in Table 4.

The current and proposed new baseline budgets are compared in Table 5, which rolls the changes up from the cost reporting level through all higher WBS levels. WBS elements not shown are unaffected by this BCR. The current baseline given in Table 5 is that as of BCR 41 (Single Stretched Wire) and BCR 43 (DFBX EDIA at FNAL), which were approved in May. Note that in Table 5, a positive (negative) change represents a proposed *increase (decrease)* in the baseline budget.

US LHC Accelerator Project	Baseline Change Request
BCR Number	42
WBS	1.1.2.5, 1.1.1.6.2, 1.1.1.6.3, 1.1.1.7.2.4, 1.1.5
Title	IR Layout and Integration
Change Control Level	2
Originator	J. Kerby / M. Lamm / R. Bossert
Date	1April 2002

Table 4 Impact of BCR 42 on FNAL-LHC BAC. (as spent $)

FNAL CPR DATA AT CHARGE CODE LEVEL (AS$ IN THOUSANDS)											
		CUMULATIVE THROUGH March 2002						BAC Change			
WBS #	Description	BCWS	BCWP	ACWP	CV	BAC	BTC (BAC-BCWP)	New BTC	VTC (new BTC-old BTC)	New BAC	BCR Change
1.1.1.2	**COLD MASS**	**58.1**	**7.1**	**7.1**	**0.0**	**88.3**	**81.2**	**89.6**	**-8.4**	**96.7**	**-8.4**
1.1.1.2.5.4.9	Bus Bar Parts	58.1	7.1	7.1	0.0	88.3	81.2	*89.6*	-8.4	96.7**	-8.4
1.1.1.6	**QUAD ASSY/TEST**	**328.3**	**206.5**	**368.2**	**-161.7**	**2,351.0**	**2,144.5**	**2,377.0**	**-232.5**	**2,583.5**	**-232.5**
1.1.1.6.2	Q2 Assy/Test	328.3	206.5	368.2	-161.7	1,853.7	1,647.2	*1,732.3*	-85.1	1,938.8*	-85.1
1.1.1.6.3	Q1/Q3 Assy/Test	0.0	0.0	0.0	0.0	497.3	497.3	*644.7*	-147.4	644.7*	-147.4
1.1.1.7.2	**COLD MASS EDIA**	**475.8**	**479.4**	**441.0**	**38.4**	**1,179.5**	**700.1**	**670.8**	**29.3**	**1,111.8**	**67.7**
1.1.1.7.2.4	Q2a/Q2b Prod'n	475.8	479.4	441.0	38.4	1,179.5	700.1	*670.8*	29.3	1,111.8**	67.7
1.1.5	**Sys Des EDIA**	**581.6**	**581.6**	**723.7**	**-142.2**	**692.9**	**111.3**	***176.0***	**-64.7**	**899.7****	**-206.8**
	TOTAL DIRECT COST	1,443.8	1,274.5	1,540.1	-265.6	4,311.7	3,037.2	3,313.4	-276.2	4,691.7	-380.0
Indirect costs	CSS/MSA	301.7	278.8	271.5	7.3	1,259.8	843.4	*959.0*	-115.6	1,375.4	-115.6
	GEN & ADMIN	154.0	137.7	158.5	-20.8						
	TOTALS	1,899.6	1,691.0	1,970.1	-279.1	5,571.5	3,880.5	5,231.3	-391.8	6,067.1	-495.6

* new BAC = old BAC - VTC
** new BAC = old BAC - VTC - CV

Table 5 Comparison of current and new baseline budgets

WBS	DESCRIPTION	BAC		
		Current	Change	BCR 42
1	FNAL LHC Accel (Total Cost)	40,749.2	495.6	41,244.8
1	FNAL LHC Accel (Direct Cost)	32,378.4	380.0	32,758.4
1.1	Interaction Reg	26,553.6	380.0	26,933.6
1.1.1	Quadrupoles	25,710.4	173.2	25,883.6
1.1.1.2	Cold Mass	5,200.2	8.4	5,208.6
1.1.1.2.5	Q2a/Q2b Parts	1,209.4	8.4	1,217.8
1.1.1.6	Quad Assy/Test	2,850.0	232.5	3,082.5
1.1.1.6.2	Q2 Assy/Test	1,853.7	85.1	1,938.8
1.1.1.6.3	Q1/Q3 Assy/Test	497.3	147.4	644.7
1.1.1.7	EDIA	9,752.1	-67.7	9,684.4
1.1.1.7.2	Cold Mass	3,732.0	-67.7	3,664.3
1.1.1.7.2.4	Q2a/Q2b	1,179.5	-67.7	1,111.8
1.1.5	System Design	692.9	206.8	899.7
	Overhead + G&A	8,370.8	115.6	8,486.4

Impact on schedule

None, other that it is imperative we close out these items so that we can move on to production status.

US LHC Accelerator Project	Baseline Change Request
BCR Number	42
WBS	1.1.2.5, 1.1.1.6.2, 1.1.1.6.3, 1.1.1.7.2.4, 1.1.5
Title	IR Layout and Integration
Change Control Level	2
Originator	J. Kerby / M. Lamm / R. Bossert
Date	1April 2002

Other impacts (ES&H, etc.)

Change Control Board recommendation (if required)

Approvals

WBS Level 3 Manager	24-JUL-02 Date
Laboratory Project Manager	24-JUL-02 Date
Change Control Board Chair	24 July 02 Date
US LHC Accelerator Project Manager	24 July 02 Date
DOE LHC Project Manager	24 July 02 Date
Director, DOE Division of High Energy Physics	Date

BCR 42 Appendix 1

"LHC IR Inner Triplet Module Assembly" Parts List

R. Bossert Last Updated 2-28-02

Item No.	Part Name	Drawing Number	Qty.	Status	Des.	Notes	Unit cost	Total Cost	x9 Assys
1	Overall Assy				KE				
1.1	Q1 Module Assembly	ME-369887	1		KE				
1.1.1	MCBX Correction Coil		1			Supplied by CERN			
1.1.2	Correction wire solder block	MB-369908	4	drawn	JS		15	60	540
1.1.3	Expansion Loop Assembly		1		KE				
1.1.3.1	Superconducting Cable						0	0	0
1.1.3.2	Copper only cable						0	0	0
1.1.3.3	Kapton Tape	MA-292722? Bare kapton?	120m			Total of 120 meters for wrapping bus	$0.30/m	36	324
1.1.4	Expansion Loop Hold Down - Fixed		1		KE		400	400	3600
1.1.5	Expansion Loop Hold Down - Sliding		1		KE		700	700	6300
1.1.6	RTD Assembly	MA-369835	4	Not drawn	JS	CERN will supply. See Jim Rife for part #	0	0	0
1.1.7	RTD Screw	MA-369892? Check # with Lee	8		JS	CERN will supply. M4 screws by 10 mm long	0	0	0
1.1.8	RTD Mounting Block	MB-369893	4	Released	LS	Probably the same as Q2	8	32	288
1.1.9	Warmup Heater	MA-369834	4	Released	JS		2	8	72
1.1.10	Warmup Heater Mounting Block		4				8	32	288
1.1.11	Warmup Heater screws		16				0	0	0
1.1.12	Q1 Instrumentation Wire Feedthru Assembly								
1.1.12.1	Instrumentation Wire Channel		1		JS		10	10	90
1.1.12.2	Instrumentation Wire Bus		1		JS				
1.1.12.2.1	RTD Wires	MA-369836				Supplied by CERN	0	0	0
1.1.12.2.2	Warmup Heater Wires	MA-369833				Supplied by CERN	0	0	0
1.1.12.2.3	Voltage Tap Wires	MA-369832				Supplied by CERN	0	0	0
1.1.12.2.4	Glass Tape		A/R					10	90
1.1.12.2.5	Kapton Tape		A/R					10	90
1.1.12.2.6	Hypertronics Connector		1				400	400	3600
1.1.13	.010 Solder Strip	MA-369904	1m	Released	JS	96% Tin/4% Silver Cost = $8/meter	$8/m	16	144
1.1.14	Kester 135 Flux		A/R				2	2	18
1.1.15	Lead Bus Splice Holder		1				50	50	450
1.1.16	Beam Tube Assembly		1			Done by cryostat team.			
1.1.16.1	Beam Tube		1			Done by cryostat team.	0	0	0
1.1.16.2	Kapton for Beam Tube		1			Done by cryostat team.	0	0	0
1.1.17	End Dome Assembly Q1 lead end		1			Done by cryostat team.	0	0	0
1.1.18	End Dome Assembly Q1 return end		1			Done by Cryostat team.	0	0	0
							Q1 Total	**1766**	**15894**

BCR 42 Appendix 1

Item No.	Part Name	Drawing Number	Qty.	Status	Des.	Notes	Unit cost	Total Cost	x9 Assys
1.2	Q2 Module Assembly	ME-369888	1	In process	JS				
1.2.1	MCBX Correction Coil Assembly	MD-390312			SM	Done by Cryostat team.			
1.2.1.1	Correction Coil MCBX	LHCMCBX_0003	1		CERN	CERN will supply	0	0	0
1.2.2	Correction coil Mounting Blocks	MC-390203	3		TP	Done by Cryostat team.	0	0	0
1.2.3	Washers	MB-390228			TP	Done by Cryostat team.	0	0	0
1.2.4	1/4 - 20 Screws	commercial			TP	Done by Cryostat team.	0	0	0
1.2.5	Silver Plated Screws	MA-390248			TP	Done by Cryostat team.	0	0	0
1.2.6	Correction wire solder block	MB-369908	4	drawn	JS		15	60	540
1.2.7	Q2 Bus Assembly	ME-369826	1	Released	JS				
1.2.7.1	Q2 Cable Bus	MB-369825	1	Released	JS				
1.2.7.1.1	Insulated soldered cable pair	MB-369823	3	Released	JS	5Ka, 8Ka, and 13Ka are identical.			
1.2.7.1.1.1	Bare soldered cable pair	MB-369822	1	Released	JS				
1.2.7.1.1.1.1	Superconducting Cable	MA-369677	1	Released	JS		0	0	0
1.2.7.1.1.1.2	Copper Cable	MA-369252	1	Released	JS		0	0	0
1.2.7.1.1.1.3	.010 Solder	MA-369904	14m	Released	JS	96% Tin/4% Silver Cost = $8/meter	$8/m	336	3024
1.2.7.1.1.1.4	Kester 135 Flux			Not drawn	JS		2	2	18
1.2.7.1.1.2	.002 x .375 bare kapton tape	MA-292722	180m	Released	HF	180 meters needed for each ind. Bus = 540m	$0.30/m?	162	1458
1.2.7.1.2	.002 x .375 bare kapton tape	MA-292722	250m	Released	HF	250 meters needed for perimeter wrap.	$0.30/m?	75	675
1.2.7.1.3	.005 x .600 kapton strip	MA-369824	2	Released	JS		10	20	180
1.2.7.2	Q2 correction coil short bus (5 pack)	MB-369882	1	Released	JS				
1.2.7.2.1	Correction coil bus wire	MB-369831	38m	Released	JS		0	0	0
1.2.7.3	Q2 correction coil long bus (5 pack)	MB-369883	1	Released	JS				
1.2.7.3.1	Correction coil bus wire	MB-369831	75m	Released	JS		0	0	0
1.2.7.4	Bus Housing - Base	MC-369668	14	Released	LS		45	630	5670
1.2.7.5	Bus Housing - Thick Cover	MC-369669	16	Released	LS		45	720	6480
1.2.7.6	Bus Housing - Thin Cover	MC-369670	2	Released	LS		40	80	720
1.2.7.7	Bus Housing Extension - Cover	MC-369865	2	Released	LS		25	50	450
1.2.7.8.	Q2a Bus Housing Extension - Base	MD-369866	1	Released	LS		75	75	675
1.2.7.9	Q2b Bus Housing Extension - Base	MD-369869	1	Released	LS		75	75	675
1.2.7.10	Bus Housing Wedge	MB-369876	4	Released	LS		20	80	720
1.2.7.11	SHCS #6-32 x 1 in long	MA-369890	148	Released	JS		0.3	44	400
1.2.7.12	FHCS #6-32 x .5 in long	MA-369891	16	Released	JS		0.3	5	43
1.2.8	Q2a Bus Housing Extension	MD-369872	1	Released	LS		70	70	630
1.2.9	Q2a Bus Housing Extension Base	MC-369873	1	Released	LS		30	30	270
1.2.10	Q2b Bus Housing Extension	MD-369867	1	Released	LS		70	70	630
1.2.11	Q2 Bus Housing Extension Cover	MB-369874	2	Released	LS		20	40	360
1.2.12	Bus Housing Lock	MB-369870	1	Released	KE		10	10	90
1.2.13	Screws for Bus Housing Lock		2	Not drawn	JS		0.5	1	9
1.2.14	RTD Assembly	MA-369835	4	Not drawn	JS	CERN will supply. See Jim Rife for part #	0	0	0
1.2.15	RTD Screw	MA-369892? Check # with Lee	8		JS	CERN will supply. M4 screws by 10 mm long	0	0	0
1.2.16	RTD Mounting Block	MB-369893	4	Released	LS		8	32	288
1.2.17	Warmup Heater	MA-369834	4	Released	JS		2	8	72
1.2.18	Warmup Heater Base Plate	MA-369829	4	Released	JS		15	60	540
1.2.19	Q2 instrumentation Wire Feedthru Assembly			Not drawn	LS				
1.2.19.1	Aluminum Channel Assembly	MC-369899	1	drawn	LS	1 1/4 x 1/2 x 1/8 wall aluminum channel	80	80	720
1.2.19.2	Q1 Feedthru Instrumentation Bus		1	Not drawn	LS				
1.2.19.2.1	Voltage Tap Wire Extensions	MA-369832	8	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.2.2	Strip Heater Wire Extensions	MA-369833	4	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.2.3	Warmup Heater Wire Extensions	MA-369833	4	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.2.4	RTD Wire Extensions	MA-369836	2	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.2.5	Glass Tape		A/R				1	10	90

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Item No.	Part Name	Drawing Number	Qty.	Status	Des.	Notes	Unit cost	Total Cost	x9 Assys
1.2.19.3	Q2a Feedthru Instrumentation Bus		1	Not drawn	LS				
1.2.19.3.1	Voltage Tap Wire Extensions	MA-369832	8	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.3.2	Warmup Heater Wire Extensions	MA-369833	2	Not drawn	JS	CERN will supply.	0	0	0
1.2.19.3.3	Glass Tape		A/R				1	10	90
1.2.19.4	Q2b Feedthru Instrumentation Bus			Not drawn	LS				
1.2.19.4.1	Warmup Heater Wire Extensions	MA-369833		Not drawn	JS	CERN will supply.	0	0	0
1.2.19.4.2	RTD Wire Extensions	MA-369836		Not drawn	JS	CERN will supply.	0	0	0
1.2.19.4.3	Glass Tape						1	10	90
1.2.19.5	Hypertronics Connector - Male		1				400	400	3600
1.2.19.6	Hypertronics Connector - Female		1				400	400	3600
1.2.19.7	Glass Tape							10	90
1.2.19.8	Kapton Tape							10	90
1.2.20	Beam Tube Assembly	MD-369802	1		JS	Done by Cryostat team.			
1.2.20.1	Beam Tube	MC-369521	1		JS	Done by Cryostat team.	0	0	0
1.2.20.2	Kapton for Beam Tube	MA-369803	1		JS	Done by Cryostat team.	0	0	0
1.2.21	Cold Bore Flange	MC-390300			TP	Done by Cryostat team.	0	0	0
1.2.22	End Dome Assembly Q2a	MD-390197	1	Released	SM	ER 6775 Done by cryostat team.	0	0	0
1.2.23	End Dome Assembly Q2b	MD-390253	1	Released	SM	Done by Cryostat team.	0	0	0
1.2.23.1	Cold Mass Bellows Assembly	MC-390073		Released	SM	ER 6774 Done by cryostat team.	0	0	0
1.2.24	Q2 Transition area Sleeve	MC-390112			SM	Done by Cryostat team.	0	0	0
1.2.25	Q2a Bus Tube Extension		1		JS	What is this?	50	50	450
1.2.26	Q2b Spider Assembly	MC-369885	2	drawn	KE				
1.2.26.1	Q2 Spider body	MD-369862	1	drawn	KE		25	50	450
1.2.26.2	Spring Plungers-Q2 spider	commercial	3		KE	McMaster Carr #84985A51	5	30	270
1.2.26.3	Retainer Clip	MB-369886	1	drawn	KE		1	6	54
1.2.26.4	Roll Pin	commercial	3	drawn	KE		1	6	54
							Q2 Total	**3807.2**	**34264.8**
1.3	Q3 Module Assembly		1		JS				
1.3.1	MCBXA Correction Coil Assembly		1		SM	Done by Cryostat team.			
1.3.1.1	MCBXA Correction Coil					CERN will supply - Made at Sigma Phi	0	0	0
1.3.2	MCBXA Correction Coil Mounting Flange					Done by Cryostat team.	0	0	0
1.3.3	MQSXA Correction Coil Assembly				SM	Done by Cryostat team.			
1.3.3.1	MQSXA Correction Coil		1			CERN will supply - Made at Sigma Phi	0	0	0
1.3.4	MQSXA Correction Coil Mounting Flange					Done by Cryostat team.	0	0	0
1.3.5	Correction wire solder block	MB-369908	8	drawn	JS		15	120	1080
1.3.6	Q3 Cable Bus Assembly		1	Not drawn	JS				
1.3.6.1	Insulated soldered cable pair	MB-369823	4	Released	JS	5Ka, 8Ka, and 13Ka are identical.			
1.3.6.1.1	Bare soldered cable pair	MB-369822	1	Released	JS				
1.3.6.1.1.1	Superconducting Cable	MA-369677	1	Released	JS		0	0	0
1.3.6.1.1.2	Copper Cable	MA-369252	1	Released	JS		0	0	0
1.3.6.1.1.3	.010 Solder	MA-369904	10m	Released	JS	96% Tin/4% Silver Cost = $8/meter	$8/m	320	2880
1.3.6.1.1.4	Kester 135 Flux			Not drawn	JS		2	2	18
1.3.6.1.2	.002 x .375 bare kapton tape	MA-292722	130m			130m x 4 busses = 520m	$0.30/m	156	1404
1.3.6.2	Q3 Cable bus housing	Lee's drawing	8	prototype	LS		20	360	3240
1.3.6.3	Glass Tape		A/R					10	90
1.3.6.4	.002 x .375 kapton w/ QI	MA-344080	240m	released	LS	Perimeter wrap. Alternate is MA-369140	$0.30/m	72	648
1.3.7	Q3 Correction coil Bus Assembly		1						
1.3.7.1	Correction coil bus (5 pack)		4			CERN will supply.	0	0	0
1.3.7.1.1	Correction coil bus wire	MB-369831	xx m	Released	JS	CERN will supply.	0	0	0
1.3.7.2	Q3 correction bus housing	Lee's drawing	8	prototype	LS		20	360	3240

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Item No.	Part Name	Drawing Number	Qty.	Status	Des.	Notes	Unit cost	Total Cost	x9 Assys
1.3.7.3	Glass Tape		A/R					10	90
1.3.7.4	.002 x .375 kapton w/ QI	MA-344080	240m	released	LS	Perimeter wrap. Alternate is MA-369140	$0.30/m	72	648
1.3.8	Bus Housing Lock		1	Not drawn	KE		10	10	90
1.3.9	MCBXA Expansion Loop Hold Down - Fixed		1		KE		400	400	3600
1.3.10	MCSXA Expansion Loop Hold Down - Sliding		1		KE		700	700	6300
1.3.11	MQBXA Expansion Loop Hold Down - Fixed		1		KE		400	400	3600
1.3.12	MQSXA Expansion Loop Hold Down - Sliding		1		KE		700	700	6300
1.3.13	RTD Assembly	MA-369835	4	Not drawn	JS	CERN will supply. See Jim Rife for part #	0	0	0
1.3.14	RTD Screw	MA-369892? Check # with Lee	8		JS	CERN will supply. M4 screws by 10 mm long	0	0	0
1.3.15	RTD Mounting Block	MB-369893	4	Released	LS	Probably the same as Q2	8	32	288
1.3.16	Warmup Heater	MA-369834	4	Released	JS		2	8	72
1.3.17	Warmup Heater Mounting Block		4				8	32	288
1.3.18	Warmup Heater screws		16				0	0	0
1.3.19	Q3 Instrumentation wire feedthru assy								
1.3.19.1	Misc. instrumentation wire tube apparatus						200	200	1800
1.3.19.2	Wires					CERN will supply	0	0	0
1.3.19.3	Hypertronics Connector - Male		1				400	400	3600
1.3.19.4	Hypertronics Connector - Female		1				400	400	3600
1.3.19.5	Glass Tape							10	90
1.3.19.6	Kapton Tape							10	90
1.3.20	Beam Tube Assembly		1			Done by cryostat team.			
1.3.20.1	Beam Tube		1			Done by cryostat team.	0	0	0
1.3.20.2	Kapton for Beam Tube		1			Done by cryostat team.	0	0	0
1.3.21	End Dome Assembly Q3 lead end		1			Done by cryostat team.	0	0	0
1.3.22	End Dome Assembly Q3 return end		1			Done by Cryostat team.	0	0	0
1.3.23	Q3 Spider Assembly		2		KE				
1.3.23.1	Q3 Spider Half	MC-369855	4	drawn	KE		10	120	1080
1.3.23.2	Spring Plungers-Q3 spider		8		KE		5	60	540
1.3.23.3	Threaded Rods		8		KE		5	60	540
1.3.23.4	Roll Pin	commercial	3	drawn	KE		1	12	108
							Q3 Total	**5036**	**45324**
1.4	Installation Kit?				KE	Is cryostat team doing some of this?			
1.4.1	Q1/Q2 Tube		1				20	20	180
1.4.2	Q1/Q2 Bellows		1			Done by Cryostat team.	0	0	0
1.4.3	Q2/Q3 Tube		1				20	20	180
1.4.4	Q2/Q3 Bellows		1			Done by Cryostat team.	0	0	0
1.4.5	Q2b Spider Assembly	MC-369885	2	drawn	KE				
1.4.5.1	Q2 Spider body	MD-369862	1	drawn	KE		25	50	450
1.4.5.2	Spring Plungers-Q2 spider	commercial	3		KE	McMaster Carr #84985A51	5	30	270
1.4.5.3	Retainer Clip	MB-369886	1	drawn	KE		1	6	54
1.4.5.4	Roll Pin	commercial	3	drawn	KE		1	6	54
							IK Total	**132**	**1188**

Grand Total	**10741.2**	**96670.8**

Labor Cost Estimate for Module Assembly Construction

R. Bossert, M. Lamm & J. Rife

Steps in production process:

				Time (person-hrs)			
Q1				182			
	Construction of Q1 Expansion Loop				18		
		Cutting Cable Sc, Cu and Corr Coil				6	
		Soldering				4	
		Insulating				8	
	Setup and alignment of cold mass				12		
	Correction coil installation				12		
		Mounting correction coil				4	
		Splicing corrector bus wires				6	
		Installing corrector coil support brackets				2	
	Installing Expansion Loop				46		
		Mounting support brackets				4	
		Forming and mounting loop				16	
		Making Splices from bus to magnet				18	
			Installing Lead Splice Holders				12
			Making Splices				6
		Adding corrector bus to loop				8	
	Mounting RTD's				4		
	Mounting Warmup Heaters				4		
	Installing Inst Wire Bus				36		
		Wrapping/insulating				16	
		Terminating wires				8	
		Installing Hypertronics connector				12	
	Securing wires to end plates & strain relief				16		
	Mounting Dome				4		
	Welding Dome				6		
	Inserting & Aligning Beam Tube				8		
	Welding Beam Tube				4		
	Setup for leak check				4		
	Final Inspection and electricals				8		

Q2				342			
	Construction of Q2 bus				136		
		Cutting Cable Sc, Cu and Corr Coil				8	
		Soldering				48	
		Insulating				64	
		Assembling Busses				16	
	Construction of Inst Wire Buss Channel				32		
		Construction of separate busses				24	
		Installation in channel				8	
	Setup and alignment of cold masses				16		
	Installing Cable & Corr Coil Bus				10		
		Sliding in and attaching bus				6	
		Making Splices to leads				4	
	Mounting RTD's				2		
	Mounting Warmup Heaters				2		
	Installing Inst Wire Bus				42		
		Sliding and wrapping				18	
		Terminating wires				8	
		Installing Hypertronics connectors				16	
	Correction coil installation				12		
		Mounting correction coil				4	
		Splicing corrector bus wires				6	
		Installing corrector coil support brackets				2	
	Securing wires to end plates & strain relief				32		
	Mounting Q2a dome				4		
	Welding Q2a dome				6		
	Mounting Q2b dome				4		
	Welding Q2b dome				6		
	Inserting & Aligning Beam Tube				8		
	Welding Beam Tube				4		
	Mounting Transition sleeve				2		
	Welding transition sleeve				12		
	Setup for leak check				4		
	Final Inspection and electricals				8		

Q3				452			
	Construction of Q3 Lead Bus Assembly				138		
		Cutting Cable Sc & Cu				8	
		Soldering				60	
		Insulating				64	
		Setup for baking				6	
	Construction of Q3 Corr coil Bus Assembly				24		
		Cutting Wire				2	
		Insulating				16	
		Setup for baking				6	
	Construction of Inst Wire Buss Channel				56		
		Construction of separate busses				48	
		Installation in channel				8	
	Setup and alignment of cold mass				12		
	Correction coil A installation				12		
		Mounting correction coil				4	
		Splicing corrector bus wires				6	
		Installing corrector coil support brackets				2	
	Correction coil B installation				12		
		Mounting correction coil				4	
		Splicing corrector bus wires				6	
		Installing corrector coil support brackets				2	
	Installing Bus assembly				52		
		Sliding in and securing bus				6	
		Making Splices from bus to magnet				18	
			Installing Lead Splice Holders				12
			Making Splices				6
		Mounting support brackets				4	
		Forming and mounting loops				16	
		Adding corrector bus to loop				8	
	Mounting RTD's				4		
	Mounting Warmup Heaters				4		
	Installing Inst Wire Bus				42		
		Sliding and wrapping				18	
		Terminating wires				8	
		Installing Hypertronics connectors				16	
	Securing wires to end plates & strain relief				32		
	Installing correction bus wires to DFBX				16		
	Installing spiders				4		
	Mounting Dome A				4		
	Welding Dome A				6		
	Mounting Dome B				4		
	Welding Dome B				6		
	Inserting & Aligning Beam Tube				8		
	Welding Beam Tube				4		
	Setup for leak check				4		
	Final inspection and electricals				8		

Total Hours 1 triplet	976
Total Hours 9 triplets	8784

Total Man-years 1 Q1	0.091
Total Man-years 1 Q2	0.171
Total Man-years 1 Q3	0.226

Total Man-years 1 triplet	0.488
Total Man-years 9 triplets	4.392

Module Assembly Production Technician Hours Required

These estimates include all items shown on p. 1-3 except alignment of cold masses, dome welding, sleeve welding, beam tube insertion and welding, hypertronics connectors, leak check and final inspection.

Production work:

Total Hours 1 Q1	124
Total Hours 1 Q2	252
Total Hours 1 Q3	380

Total Hours 1 triplet	756
Total Hours 9 triplets	6804

Total Man-years 1 Q1	0.062
Total Man-years 1 Q2	0.126
Total Man-years 1 Q3	0.19

Total Man-years 1 triplet	0.378
Total Man-years 9 triplets	3.402

R&D yet to come as of 4-2-02:

Mockup work:

Man-hours on mockup	350
R & D on splices	0
Extra hours for first triplet	350
Total R & D in Man-hours	700

Grand Total including R & D:

Man-years on 9 triplets (prod)	3.402
Man-years R & D	0.35
Total Man-years	3.752

Expected % time charged to LHC Budget Codes for designers & Engineers FY2002

		April	May	June	July	August	September			
R. Bossert	LLI	25%	25%	25%	25%	25%	25%	218.8		LLI Engr
R. Bossert	EQB	25%	25%	25%	25%	25%	25%	218.8		EQB Engr
Total R. Bossert		50%	50%	50%	50%	50%	50%			
L. Simmons	LLI	100%						145.8		
K. Ewald	LLI	50%	25%	25%	25%	25%		218.8	364.6	LLI Designer
J. Sachtschale	LLI	75%	50%	50%	50%	50%		401.0		LLI Drafter
J. Sachtschale	EQB	25%					50%	109.4		EQB Drafter
Total J. Sachtschale		100%	50%	50%	50%	50%	50%			

So totals for FY2002 (in man-months) are:

LLI = 6.75
EQB = 3.75
Total = 10.5

After FY2002, John Sachtschale and Rodger Bossert are expected to be charging some percentage (50%?) for the balance of the project.

EQB = 1.1.1.7.2.4 Q2a/Q2b Cold Mass Production EDIA
LLI = 1.1.5 IR System Design